Politehnica University Timișoara
Faculty of Chemical Engineering, Biotechnologies and Environmental Protection
Department of Applied Chemistry and Engineering of Organic and Natural Compounds

HABILITATION THESIS

Doctoral Field: Chemical Engineering

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Abstract

The habilitation thesis entitled “Sustainable and green directed biocatalytic pathways as innovative strategies in chemical processes” outlines Dr. Anamaria Todea's scientific and professional achievements since completing her PhD, highlighting her contributions to sustainable biocatalysis and green chemistry through international collaborations and multidisciplinary research.

A significant part of the research involved enzyme immobilization using physical (adsorption), chemical (covalent binding and sol–gel entrapment) or combined techniques to significantly improve their thermal and operational stability. These immobilised biocatalysts were then integrated into batch and continuous flow systems (packed-bed reactors) to enable the scalable, reproducible and environmentally friendly synthesis of enantiopure secondary alcohols, aroma esters and sugar esters in solventless or non-conventional reaction media.

A second direction of the thesis is focused on the enzymatic synthesis of bio-based oligoesters, which are intermediates for biodegradable materials, functional ingredients and speciality chemicals. The studies utilised renewable building blocks, including sugar derivatives, fatty acids derived from vegetable oils and natural alcohols such as glycerol, as substrates in enzyme-catalysed esterification and polycondensation reactions. The utilization of biocatalysts, particularly lipases, enabled milder reaction conditions, high selectivity and reduced the environmental impact.

The resulting polyesters' biodegradability was systematically investigated in different liquid media, and structure–degradability relationships were established. Notably, the hydrophobicity and crystallinity of the polymers were found to affect their degradation kinetics, offering valuable insights into the design of eco-friendly materials. This research also introduced the concept of safe-and-sustainable-by-design, incorporating ecotoxicological evaluation and rational oligoesters and monomer selection based on environmental and functional criteria.

The thesis reflects a robust scientific portfolio, supported by eight international academic collaborations and several research projects accomplished within European and national frameworks. It includes over 50 peer-reviewed publications, numerous invited presentations, and active participation in the education and mentoring of students at bachelor, MSc, and PhD levels. These achievements demonstrate technical expertise in biocatalysis and polymer science, as well as leadership and vision in implementing sustainable solutions in chemical and biochemical engineering.

Integrating experimental enzymology, green chemistry strategies and materials engineering, this thesis demonstrates the potential of the biocatalytic technologies to reduce the utilization of hazardous chemicals and the high energy demand characteristic for the traditional synthesis methods. The results have direct applications in the fields of biodegradable packaging, green cosmetics, food additives and functional bio-based polymers, establishing biocatalysis as a transformative tool in the modern chemical industry.